SEARCH Atmospheric Element 3:
Atmospheric Observatory

YEAR 1 PROGRESS REPORT

To the
National Oceanic and Atmospheric Administration (NOAA)
for funding under the SEARCH program

Reporting period:
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FY03 SEARCH Annual Report
Title: Atmospheric Observatory (Element 3)

Objective: The objective of NOAA/SEARCH Element 3 is to establish a cooperative, long-term Atmospheric Observatory to monitor radiation, clouds and aerosols in North-East Canada. The Observatory will mirror many of the measurements already being taken in Barrow, Alaska (NOAA/CMDL and DOE/ARM) so that direct comparison can be made between two markedly different Arctic regimes. The target area for the Observatory will be northeast Canada which has been identified as the center of AO related cooling. Primary institutional participants are the U.S. National Oceanic and Atmospheric Administration (NOAA), Meteorological Services Canada (MSC), University of Toronto (CANDAC Program) and University of Wisconsin. Preliminary activities are laying the ground work for a second NOAA/SEARCH Atmospheric Observatory that will be in central Siberia. Siberia has been identified as the center of AO related warming. Russian activities are not yet funded and in planning stages only.

Personnel:
In addition to the PIs and Collaborators listed on the cover page of this report, personnel include Russ Schnell, Ells Dutton, Sharma Sangeeta, (consultation on and construction of broad-band radiation suite), Ken Moran (consultation on and system upgrades for the cloud radar), Marian Klein and Al Gaswieski (construction of ground-based scanning radiometer – GSR), Ola Persson (flux measurements and analysis), Matthew Shupe (data integration), and Sergey Matrosov (Siberian Observatory activities).

Accomplishments to Date:
The original milestones proposed for this project in the first year were:

- Develop partnership agreements with U.S. Agencies and International Programs with common monitoring and research interests
- Make final site selection
- Design the SEARCH Atmospheric Observatory with integrated shelter, power, maintenance, and data protocols
- Purchase and construct BSRN grade radiometric suite
- Begin acquisition of parts and construction of microwave/IR radiometer
- Design and purchase some parts for replacement* radar
- Begin development of an integrated data base for all instruments

These milestones are discussed in the sections below.

<u>Develop partnership agreements with U.S. Agencies and International Programs with common monitoring and research interests</u>
The primary collaborators that have been identified are MSC (Meteorological Services Canada), CANDAC (Canadian Network for Detection of Atmospheric Change), and the University of Wisconsin Lidar Group. To date there has been one introductory teleconference call (June 2nd, 2003), 1 meeting to discuss concept and joint interests (Aug 18th, 2003 in Toronto) and one logistics meeting (January 12-13, 2004 in Boulder) during

which personnel from NOAA and MSC formulated specific plans to deploy a radiometric suite in Alert in the summer of 2004. The results of these meetings can be viewed at:

http:///www.etl.noaa.gov/projects/search/Telecon_June_2003.pdf
http://www.etl.noaa.gov/projects/search/BoulderMeeting_Jan11to12.pdf
http://www.etl.noaa.gov/projects/search/ALERT_EUREKA_AUG2003.PDF

There has been a clear recognition by all participants that there are a large number of joint science and climate monitoring issues/needs that will be facilitated by cooperation between countries and institutes. An MOU (Memorandum of Understanding) process is being investigated to determine how agreements between MSC and NOAA will be structured; and it appears likely that the NOAA/SEARCH Observatory activities can be annexed to an existing MSC-NOAA MOU entitled: "Cooperation in Environmental Data Acquisition and Utilization". There remain a large number of logistical details that need to be resolved, and the Observatory program plan has been evolving to accommodate changing situations and resources. For instance recent news that the new Canadian Network for Detection of Atmospheric Change (CANDAC) program had been approved for substantial funding to establish observations in Eureka may have a substantial positive effect on the NOAA/SEARCH Observatory program.

A contact has been established with the Japanese National Institute of Polar Research (NIPR) and there exists some possibility of collaboration with this institution, especially in the area of contaminant measurements. SEARCH atmosphere activities have also been briefly presented to Chinese Arctic and Antarctic Commission.

Future possibilities for a second observatory in Russia are being pursued. Of all regions of the circum-Arctic, northern Siberia is perhaps the most devoid of climate monitoring activity related to cloud and aerosol studies. Although, high quality historical records exist from several island and coastal stations, the demise of the Soviet Union and subsequent economic decline resulted in closure and decay of most stations in the network. At the same time, profound changes in the climate of this region have taking place. As an initial step, NOAA/SEARCH participants from ARO, CMDL and ETL drafted a proposal for a joint U.S. - Russian Atmospheric Climate Observatory in 2003. This was translated into Russian and sent to joint members of the Russian Academy of Science and Roshydromet. The proposal was discussed at November 2003 meetings in St Petersburg with prospective collaborators at the Arctic and Antarctic Research Institute (AARI) as well as in Moscow with officials at Roshydromet.

Make final site selection

NOAA organized a site visit on August 19th to 22nd that included representatives from NOAA (Uttal, Stone), MSC (Howe, Platt, McArthur), University of Wisconsin (Eloranta), University of Toronto (Drummond) and NIPR (Ushio) to Eureka (80.05N 86.43W) and Alert (82.3N, 62.3W) in the newly established Canadian territory of Nunavut. The visit was preceded by discussions in Toronto to assess the feasibility of long-term operation of atmospheric measuring instruments including radar, lidar, MW

and IR radiometers, surface aerosol measurements, broad-band radiometers, and standard meteorological and surface measurements. The site survey report is available at:

http://www.etl.noaa.gov/projects/search/ALERT_EUREKA_AUG2003.PDF

Science Issues:
Alert (Figure 1) is attractive because of ongoing measurements from a Global Atmosphere Watch station which provides a long time-series of ongoing measurements of aerosols and contaminants. Alert is a coastal site which provides access to the Lincoln Sea, and is the closest inhabited land station to the North Pole (about 850 km). The terrain in the immediate area of proposed Observatory measurements is relatively flat and homogeneous over a wide area and appears suitable for monitoring a climate regime that will be representative of this region of the high Arctic. There is a large, structurally sound, available building in Alert that looks extremely suitable for Observatory instruments.

Eureka (Figure 2) is attractive because of possible coordination with the Canadian CANDAC that has recently secured funding ($3.3M CND with a likely additional matching 3.3M CND) for reopening the Eureka AstroLab. CANDAC has proposed to operate many of the same atmospheric sensors as the NOAA/SEARCH Observatory program, therefore, there exists significant opportunity for leveraged activities. The AstroLab is a state-of-the-art facility located at 2000 ft altitude which has been built with rooftop platforms and power to accommodate atmospheric instruments and has such amenities as rooftop hatches for lidars. Eureka is a preferable to Alert as ground site for satellite validation due to overpass geometries which make it of interest to the NASA and Canadian Space Agency CLDSAT program. Eureka has substantially more complex local terrain than Alert; it is located within the Canadian Archipelago and is surrounded by a patchwork of mountains, valleys and fjords. The relative location/elevations of the MSC weather station (sea-level) and the Astrolab (~2000 ft) provide an opportunity for measuring both clouds from sea-level with active sensors and making in-cloud measurements of cloud and aerosol properties to further research aerosol-cloud indirect effects.

Both Eureka and Alert have a long time-series of existing meteorological measurements, and some ice measurements on neighboring lakes and fjords.

Logistics
Alert is a military base operated by the Canadian Department of National Defense (DND). Eureka is a MSC Weather Station with a more limited military presence as it is the location of a satellite uplink station. Both sites offer excellent infrastructure in terms of buildings, power, telecommunications, and have workable transportation and housing options. In general, Alert probably offers the possibility of more cost effective operations support because of military subsidization of housing/transportation, and the opportunity to cost-share the services provided by the GAW station technicians. MSC has acquired use of a large structure in Alert referred to as the TX building that would be ideal in terms of location, telecommunications, structural integrity and access.

Figure 1 Global Atmosphere Watch station in Alert

Eureka does not have such an obvious existing building for housing the NOAA/SEARCH Observatory instruments near the weather station. Although the Astrolab will be ideal for in-situ cloud and aerosol measurements, is unsuitable as a site for the cloud radar and cloud/aerosol lidar as it is often above cloud base. Eureka has annual ice breaker visits and Alert is serviced by Hercules aircraft based out of Thule. Transportation and housing for personnel is likely to be much more expensive at Eureka as opposed to Alert due to considerable military subsidy in Alert.

Alert has an official policy of only allowing Canadian civilians on base. While the ongoing unofficial policy has been, and will likely continue to be much less restrictive, especially for US citizens, it appears that Russian scientists will not have the option to visit the base at any time in the foreseeable future. Because the NOAA/SEARCH program is intended to be an international partnership, it is critical that the primary site be a location that will be accessible to scientists of all nationalities.

Balance of issues has resulted in a plan that will take advantages of both sites utilizing a distributed observing strategy. This was in fact suggested at the initial MSC-NOAA teleconference and continues to seem a viable course of action. The Alert site will be the location of a spring/summer 2004 deployment of NOAA aerosol sensors and the broad-band radiation suite. These will be particularly useful measurements that will

complement the long-term GAW station measurements. The second and third year deployment of the cloud radar, cloud-aerosol lidar, and scanning radiometer will be in Eureka. Eventual plans will be to install a second set of surface aerosol sensors and broad-band radiation sensors in Eureka which will provide a set of coordinated measurements between sites.

Figure 2 Astro Laboratory in Eureka

Design the SEARCH Atmospheric Observatory with integrated shelter, power, maintenance, and data protocols

There has been no significant process on this element as it has not yet been determined if NOAA/SEARCH will be operating from a insulated, portable seatainer, or from an existing building.

Purchase and construct BSRN grade radiometric suite

Surface radiation measurements have been made historically at Alert for many years using radiometers that are currently deemed inadequate to produce data of sufficient quality needed for climate studies. It is the intention of NOAA/SEARCH to operate to fulfill BSRN (Baseline Surface Radiation Network) standards. Additionally, sunphotometers will be used to measure aerosol optical depth (AOD).

A BSRN grade suite of broad-band radiation sensors has been purchased and is presently being assembled by NOAA/CMDL. NOAA/CMDL personnel are consulting with MSC to provide concrete pads and footings to facilitate deployment in August 2004 at the Alert military base. There arose a number of issues because of somewhat differing operation protocols between MSC and NOAA for these kinds of instruments, but it appears that a satisfactory compromise has been reached that succeeds in facilitating both NOAA/SEARCH and MSC/BSRN objectives. It is expected that deployment will occur in August of 2004.

Table 1 lists the instrumentation and components that make up the standard BSRN package, plus ancillary measurements needed for data interpretations. In all some 15 individual instruments will generate 26 data streams from which 20 measurements will be derived to define the net surface radiation budget, the local meteorology and snow chronology, and spectral properties of atmospheric aerosols. Data will be transmitted daily via modem and satellite uplink to Boulder and on to MSC-Canada where a subset of BSRN data will be quality assured and submitted to the global BSRN archive. The complete data set will be merged and quality checked before being archived at CMDL-Boulder. All data will be archived as one-minute values for high temporal process studies as well as long-term trend analyses.

Table 1 Broad-Band Radiation Suite Instruments

	Measurements	Derived Quantities	Notes
Standard Met Package; Thermistors, Hygrometer, anemometers, PC (NIPHER) gauge, snow depth gauge	**T, RH, P, WS, WD,** snow depth, Precipitation T at 2m and at 4m	- inversion strength - Tair-Tskin differences	**Incorporate with BSRN Snowdepth gauge mounts on boom of albedo rack** **T-probe at 2 m on mast of rack** **T-probe 4 m at walk up tower**
Total Sky Imager ??? (TSI-880)	**Visible hemispheric cloud images**	**Cloud fraction**	**Daylight only Year 2/3 ?**
Eppley Pryheliometer NIP	**Direct beam flux**	**Direct component**	**BSRN**
Kipp and Zonen Pyranometer CM22	**Shaded broadband SW flux**	**Diffuse Sky component**	**BSRN**
Epply Pyrgeometer Model PIR (2 systems)	**Broadband IR (up and down)**	**NET longwave flux**	**BSRN**
Kipp and Zonen Pyranometer CM22 (2 systems)	**Broadband (up and down)**	**NET shortwave flux**	**BSRN**
8-channel Sun photometer System (Carter Scott SP02s)	**Spectral radiance (367,412,500,615, 675,778,862,1050)**	**Aerosol Optical Depth**	**Mounts to solar tracker**
Pair LICOR sensors, aspirated	**Up, down solar flux**	**Albedo of partial solar spectrum**	**Mount on albedo rack next to CM22**

Begin acquisition of parts and construction of microwave/IR radiometer

The ground-based scanning radiometer is a developmental scanning instrument based on a similar aircraft mounted system. It is designed with a rotating drum with available bays for channels at 18, 21, 37, 55, 89, 183, 340 GHz and an IR thermometer at 10 microns. In this reporting period, parts have been purchased for the 21, 55, 183 GHz and 10 micron channels, as well as a number of the rotating drum and accessories for the housing. The 183 GHz channel will provide significantly more sensitivity to atmospheric vapor and liquid than commercially available 21 and 37 GHz radiometers. The 55 GHz channel will eventually provide temperature profiles. A ground-based prototype was completed in March of 2004 and deployed in Barrow Alaska (Figure 1). T. Uttal assisted with operations and assessment of the instrument; it appears to have run successfully at temperatures to -40 C and in conditions of high winds and blowing snow.

Figure 3 Maiden deployment of prototype GSR in Barrow, Alaska, March 10, 2004.

Design and purchase some parts for replacement radar

The DOE/ARM 35 GHz cloud radars have recently been receiving upgraded processors, with the NSA radar processor installation scheduled for April 2004. The SEARCH 35 GHz cloud radar has also had received an identical processor upgrade. Thus, data formats, spare parts supplies and data processing procedures will still be identical between the DOE/NSA and SEARCH Observatory radar systems.

As stated in the year one plan, SEARCH funding is being utilized to build a 94 GHz radar for the NOAA PACS/EPIC programs (scheduled annual deployments on the R/V Ron Brown) to free the ETL 35 GHz cloud radar from programmatic responsibilities. This was determined to be a cost effective solutions for both the PACS and SEARCH programs. A number of design efforts were investigated for the new 94 Ghz radar, and the specifications have been written for the RF up/down converter for use with a TWT transmitter. A number of 94 GHz radar parts have been purchased including a 3 foot cassegrain antenna, circulator, and others. Assembly has not commenced on the new radar.

The University of Wisconsin Arctic HSRL lidar is completed and operating, however a deployment proposal to NSF has been recently declined. The NOAA/SEARCH Observatory program is evaluating budgets to determine how much of lidar deployment can be supported through Observatory funding.

Begin development of an integrated data base for all instruments

Data sets from the University of Wisconsin lidar and the ETL ground-based scanning radiometer have only recently become available, and the cloud radars for NSA and SEARCH have not yet operated with the new processing system that will result in modified data formats. Therefore, progress on this element has been delayed until the second year.

Additional Accomplishments

A number of programmatic opportunities were utilized to advance the aerosols component of the NOAA/SEARCH Observatory program in the first year. Arctic aerosols have been monitored by the Meteorological Service of Canada (MSC) and the U.S. National Oceanic and Atmospheric Administration (NOAA) for nearly three decades at their stations in Alert and Barrow, respectively. In response to growing concerns about the role of aerosols as forcing agents of climate change, both MSC and NOAA are enhancing their Arctic aerosol measurement programs. Aerosol researchers at MSC and NOAA collaborated to upgrade and operate the aerosol monitoring system at Alert in March of 2004. The eventual outcome of this collaborative project will be identical systems for monitoring aerosols at Alert and Barrow, which can be combined to provide an improved understanding of the interactions among aerosols, clouds, and climate in the Arctic.

This section summarizes the current status of that collaboration. The aerosol sampling inlet at Alert was built to the same design as the inlet at Barrow, ensuring that aerosol samples from the two sites are collected under comparable conditions. Both stations use sampling protocols consistent with the guidelines recommended by the WMO Global Atmosphere Watch (Aerosol Measurement Procedures, Guidelines and Recommendations, WMO/GAW report no. 153, WMO TD no. 1178, September, 2003). MSC operates two instruments for measuring aerosol light absorption at Alert, an aethalometer (Model AE6, Magee Scientific, Berkeley, USA) and a particle/soot absorption photometer (Model PSAP, Radiance Research, Seattle, USA). In March, 2004, MSC deployed an integrating nephelometer to measure aerosol light scattering at Alert

(Model 3563, TSI, St. Paul, USA). The NOAA/SEARCH program is contributed a condensation particle counter (CPC, Model 3010, TSI, St. Paul, USA) and a data acquisition system for Alert, which was deployed at the same time as the nephelometer. The NOAA data system runs on a laptop computer (IBM Thinkpad T20) running RedHat Linux (version 9), and the source code for the NOAA system is freely available upon request. Data from the upgraded system at Alert will be transmitted daily to MSC headquarters in Downsview, Ontario, with a copy forwarded to NOAA's Climate Monitoring and Diagnostics Laboratory (CMDL) in Boulder, Colorado. The Alert data will be processed automatically at CMDL, using the same procedures and data formats as are used for CMDL's aerosol monitoring stations at Barrow and elsewhere, and preliminary results will be available for immediate viewing on a web site maintained by CMDL (http://www.cmdl.noaa.gov/aero/net/alt/index.html). Quality control checks and final data editing will be the responsibility of MSC, and CMDL will provide copies of aerosol data processing and editing software to facilitate generation of the final data files. The final data will be archived at both MSC and NOAA/CMDL, and will be publicly accessible via the Internet.

A second upgrade is planned for August, 2004, in conjunction with deployment of the NOAA/SEARCH radiation suite at Alert. At this time, an impactor system for delivering size segregated samples to the aerosol samplers (nephelometer and PSAP) will be installed. Under the control of MSC's data logger, an electrically-actuated ball valve will switch the sample flow through a 10-um or 1-um inertial impactor every six minutes. Identical switched impactor systems are used to provide comparable size-resolved samples at Barrow and most other NOAA aerosol monitoring stations. Construction of the switched impactor system for Alert will be a shared undertaking: the impactors for this system will by built by NOAA's Pacific Marine Environmental Laboratory (PMEL) with funding from MSC; the flow system will be fabricated by CMDL with funding from SEARCH; and MSC will provide the mass flow controller and will be responsible for final assembly. The MSC data logger will record the flow rate and control the ball valve. The clocks in the NOAA and MSC data loggers will be synchronized with a GPS based time standard to ensure that data from the MSC logger can be subsequently merged with data from the NOAA system. MSC will be responsible for operating the aerosol sampling system at Alert, which includes changing filters in the PSAP and aethalometer, maintaining the butanol supply for the CPC, regular calibration checks of the nephelometer with pure carbon dioxide, and transmission of data to Downsview and Boulder.

CMDL will maintain a web page for the Alert aerosol system, will be responsible for preliminary processing for the aerosol data, and will maintain and service the aerosol data acquisition system. The latter task will require remote access to the aerosol computer at Alert, following security procedures established by MSC and NOAA. NOAA has purchased a condensation particle counter and a data acquisition system that will be deployed in March of 2004 along with a new MSC integrating nephelometer. These instruments will complement existing measurements by the MSC aethalometer, and a particle/soot photometer. In August of 2004 plans are for deploying an impactor system

for delivering size segregated samples to the aerosol samplers. The impactor system will be shared MSC and NOAA undertaking.

Milestones for the FY2004

- Install BSRN –grade radiation suite in Alert
- Install aerosol impactor system in Alert
- Continue construction of 94 GHz radar
- Continue construction of Ground-Based Scanning (GSR) radiometer
- Analyze initial data sets from GSR, HSRL lidar and new 35 GHz radar processor
- Establish MOU with MSC and CANDAC

Summary of Financial Expenditures to Date

ETL Expenditures for FY2003 (A8R1PSEP63)

Salaries:	$ 32,122
Travel:	$ 27,124
Contract Labor:	$ 58,665
Contract O/H:	$ 5,301
Equipment:	$188,665
Lost C/O *	$ 28,323
Total:	$340,200

*Misfiled PO resulted in funds not being spent by expiration date. These funds are not recoverable.

ETL Contributions to NOAA/SEARCH for FY2003 (38R2N14P6D)

Salaries:	$ 98,678
Travel:	$ 455
Equipment:	$?
	$ 99,133 +

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CMDL Expenditures for FY2003 (?)

Salaries:	$ 56,123
Equipment:	$ 40,512
Expendables	$ 30,485
O/H, supplies	
	$127,150

Element 3 Budget Request for FY2004
FY2003 allocation was: $350,200 (ETL) + $127,150 (CMDL) = $467,350
FY2004 allocation request is**: $382,145 (ETL) + $85,205 (CMDL)** = $467,350

See Separate Excel Budget Explanation. (FY2004 items highlighted in yellow)